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Tune In, Turn On, Drop Out

Section 108(c) and Evaluating Deterioration in Commercially Produced VHS Collections

Walter Forsberg and Erik Piil

ABSTRACT

Analog videotape, an imperfect moving image technology format since its introduction, is reaching the end of its life cycle. However, large quantities of out-of-print and irreplaceable VHS titles still comprise significant portions of library and archival collections and circulations. Given the need to preserve this content, this study investigates the use of the "dropout" metric (counts of disruptions in the video signal) for determining whether libraries and archives can invoke their rights of reproduction under the United States Copyright Act. Videotape technology and deterioration problems are explained and prior deterioration studies are reviewed. Dropout tests of four pairs of commercially produced VHS titles are conducted and relationships between videotape deterioration as measured by dropout counts, circulation statistics, and manufacturing quality control standards are evaluated. Offering noninvasive evidence of videotape deterioration, quantified dropout counts appear to provide libraries and archives with an objective measure to meet the vague "deterioration" standard of the Copyright Act.

INTRODUCTION

Particularly among research-level university institutions, circulating library collections still consist of large amounts of VHS videotape. With the advent of "peak-VHS" sales in 1998, and the 2008 announcement of commercial discontinuation by its "final supplier" (wholesaler Distribution Video and Audio), university libraries defaulted to become some of the most significant North American entities still

annually dealing with substantive quantities of the videotape format (Simon & Kugler, 2008). Faculty preferences, budgetary limitations, and the unavailability on subsequent formats of content originally held and acquired on VHS, all contribute to these institutions' continued reliance on this practically obsolete format. As one example, the Avery Fisher Center for Music and Media at New York University (NYU) Libraries recorded 4,371 checkouts of VHS tapes from 2011 to 2012, representing nearly 15% of its total circulation for video materials. Four years prior, VHS circulation stood at half of that of titles on DVD.

During this decade-long period of decline for VHS as a moving image user format in consumer spheres, the landscape of media use in libraries radically changed. Information management and delivery mechanisms met a period of rapid technological development and deployment. Impacted directly by the Internet, library patron expectations expanded across diversifying technological strata where speed of delivery, facility of discovery, and digital access became the new normal. The trending obsolescence of VHS "fast-forwarded" alongside these shifts, as content became available on DVD and BluRay, and as digital files through internal and external streaming services. Citing the growing unavailability of VCRs, a wave of quiet notifications by institutional information technology (IT) departments now inform media librarians and faculty that support of VHS playback will soon draw to a close. As one recent contributor to the VIDEOLIB listserv characterized it, "VHS death went from a lingering, gradual one (to which we seem to be slowly adapting) to a quick bullet to the head."[1]

This "VHS death" in libraries is troubling for a host of reasons. Immense resources have been expended on growing libraries' research and teaching collections in a format they are being told will soon be unusable. Furthermore, a significant portion of content held on VHS is out-of-print or unavailable on other formats (though, few libraries have undertaken the required research to systematically determine what the scope of this unavailability is). Many librarians are ill-equipped with limited institutional support, financial budgets, specialized hardware, or technical knowledge needed to perform preservation of their videotape collections in-house, or through a third-party vendor. For these reasons, and others, circulating videotape collections in libraries are critically threatened.

What is frustrating, in the face of these circumstances, is the fact that fair use rights afforded under Section 107 of the United States Copyright Act actually exist to make copies for the sake of preservation. Congress, even, explicitly mentions that preservation of deteriorating moving images on aging formats is an activity that "certainly" qualifies as a fair use.[2] Furthermore, Section 108 of the United States Copyright Act explicitly provides an additional special exemption for libraries and archives to make copies of material held on obsolete formats, and for material that is "damaged, or deteriorated." Yet, many libraries have remained timid and inert about preservation reformatting for commercially produced circulating VHS collections.

This chapter is an attempt to buoy the confidence of libraries in their present (or, yet unrealized) efforts to digitally preserve their at-risk analog circulating VHS

collections. With specific attention to deciphering the vague and format-agnostic legal qualification of "deteriorating" required under Section 108(c), this paper presents a survey of magnetic media deterioration studies. Considering dropout as a key practical metric for deterioration determination, we propose and employ a methodology, and present results from technical tests undertaken at DuArt Film and Video with VHS videotapes from New York University Libraries collections at the Avery Fisher Center for Media (AFC), conducted as part of the Andrew W. Mellon Foundation-funded project, Video At Risk: Strategies for Preserving Commercial Video Collections in Libraries.

SECTION 108(c) AND MAKING COPIES

Aside from fair use rights of reproduction for preservation purposes set forth in Section 107 of the Copyright Act, under specific circumstances libraries and archives possess additional legal rights for making copies of material for which they do not own copyrights. Section 108(c) of the United States Copyright Act provides an exemption for libraries and archives to make copies of copyrighted material if a copy of a work belonging to a library or archive is "damaged, deteriorating, lost or stolen," provided no replacement copy can be found in the marketplace, and resultant (no more than three) new copies are not circulated to the public outside the premises. These copies can be digital copies. As the statute states:

> (c) the right of reproduction under this section [i.e., § 108] applies to three copies or phonorecords of a published work duplicated solely for the purpose of replacement of a copy or phonorecord that is damaged, deteriorating, lost or stolen, or if the existing format in which the work is stored has become obsolete, if—
>
> (1) the library or archives has, after a reasonable effort, determined that an unused replacement cannot be obtained at a fair price; and
>
> (2) any such copy or phonorecord that is reproduced in digital format is not made available to the public in that format outside the premises of the library or archives in lawful possession of such copy.
>
> For purposes of this subsection, a format shall be considered obsolete if the machine or device necessary to render perceptible a work stored in that format is no longer manufactured or is no longer reasonably available in the commercial marketplace. (17 U.S.C. § 108(c))

The existence of manufacturers still producing combination VHS/DVD playback machinery likely disqualifies VHS from being safely considered an "obsolete" format, according to a conservative interpretation of legal language. Thus, while the terms "lost" and "stolen" conditions are self-evident (if paradoxical, in practical terms of the ability to make a copy of an absent item), and the term "damaged" somewhat less so, the statute's failure to define the term "deteriorating" prompts the current inquiry.

VIDEOTAPE TECHNOLOGY

Articulating the aspects of deterioration in analog VHS tapes first requires a brief recap of what videotape technology is, and how it basically works. Analog videotape stores magnetically encoded electrical information to represent recorded sound and moving images. Through a complex technological language of electromagnetic engineering, a magnetizable layer of (most often) ferric oxide in polyurethane binder is evenly applied to a thin film polyester base and serves as a carrier for every manner of content in broadcast, educational, and home theater markets. Other binder materials have been employed; however, those described above have been the most common and widespread methods with regards to the VHS format considered in the experimental study, below.

For a half-century, across dozens of video format platforms, magnetic tape manufacturers sought to improve videotape stability and performance by experimenting with various "recipes" for this magnetic binder. From several metal particle formulations of ferric oxide, cobalt ferrite, and chromium dioxide, to other metal-evaporated tape formulations, these variations in binder makeup largely remain undisclosed trade secrets. While manufacturers made advances in binder density capacity, and introduced many subsequent analog and digital tape formats, the imperfections inherent in magnetic videotape recording were never completely eliminated; attempts at alleviating them continue to this day in the field of magnetic storage for data. As an organic carrier, videotape naturally experiences some degree of physical change of state with use and over time. The stability of information stored using this technological memory system—a kind of semi-hard "rust soup" on plastic strips—is subject to a wide array of liabilities and potential points of failure that can contribute to deterioration.

WHAT CONSTITUTES DETERIORATION IN MAGNETIC VIDEOTAPE?

Relevant Previous Deterioration Testing

A modest body of scientific scholarship exists relating to experimentation employing chemical analyses of videotape binders, documenting their instability and susceptibility to breakdown caused by moisture absorption, known as "hydrolysis." One 1993 publication saw British scientists and the Agfa Gevaert company collaborating on measuring naturally and accelerated-aged tapes using Fourier Transform infrared (FTIR) spectroscopy to determine the resilience of polymer chains in the magnetic binder, with specific emphasis on the impact of hydrolysis. Their work scientifically reiterated the central role binder hydrolysis plays in videotape deterioration (in lieu of organic breakdown in the polyester film base), yet did not specifically consider the factor of repeated playback (Edge, Allen, Hayes, Jewitt, Brems, & Horrie, 1993, pp. 207–214). A recent Institute for Museum and Library Services grant awarded

to researchers at the University of South Carolina in collaboration with the Library of Congress supports the development of a rapid, nondestructive, degradation-identification tool using infrafed (IR) spectroscopy and an IR spectral database for determining deterioration. Other studies often also document hydrolysis breakdown of tape binder via optical magnification, using scanning electron microscopes (SEMs) (Gilmour, 2000). Such SEM-based approaches can provide visual evidence of changes in the surface of the videotape binder, including impurities on the tape surface caused by binder breakdown and deterioration.

Other studies consider the role of repeated playback in precipitating physical videotape binder deterioration. A 1992 peer-reviewed published test by several engineers at Sony considered the effects of repeated video head wear on an immobilized videotape track in "still mode." Their test methodology revealed physical portions of the tape binder to be removed by rotary heads of a three-head VTR spinning over the same surface area at ninety cycles per second, citing several physical stress responses of the inherently uneven surface of magnetic tape (Osaki, Oyanagi, Aonuma, Kanou, & Kurihara, 1992, pp. 76–83). The repeated physical contact between head and tape in this test parallels some use concepts for the current study we describe; however, the authors' detail in describing their metric for documenting performance loss in the videotape is vague.

In a 1999 paper, a United Kingdom-based police unit considered the effect multiple recording passes had on diminishing ability to remagnetize tape binder with different recorded content. Using visual test pattern charts, the Police Scientific Development Branch sought to determine the number of times closed-circuit television (CCTV) systems might reuse a single videotape to record new (and, not merely repeatedly playback the same) security camera footage, determining that after an average maximum of twelve recording passes deterioration of the videotape binder resulted in unacceptable visual quality. Again, it is worth noting that their methodology was dependent on subjective human visual assessments of the test charts they employed (Mather & Neil, 1998, pp. 220–224). While such rerecording and magnetic remanence investigations are less pertinent to investigating playback performance of material recorded only once, they serve to reiterate the complexity of the chemical and organic processes with regard to videotape performance.

One playback-based study by the British Broadcasting Corporation in 2000 found that over 45% of the 2,800 ¾-inch U-matic videotapes digitized required that "technical comments" be made during transfer (Lee, Prytherich, & King, 2000, pp. 177–186). This study, however, did not speculate as to whether problematic playback issues (such as incorrect audio levels, "low RF," and "noisy/low-quality pictures") were by-products of the original recording process, or the age of the tapes at the time of transfer (all of which were between eleven and eighteen years old).

As Jean-Louis Bigourdan, James M. Reilly, Karen Santoro, and Gene Salesin of the Image Permanence Institute observed in a 2006 National Endowment for the Humanities final report, articulating and documenting videotape degradation with any degree of specificity is a challenging and under-sophisticated reality (Bigourdan,

Reilly, Santoro, & Salesin, 2006, p. 15). Across the extant scholarship, at some point along the spectrum of testing, analysis, and comparison, a lack of condition assessment (most often, at the moment of creation or acquisition) renders any subsequent condition without a comparative counterpoint.

One of the most in-depth studies on videotape deterioration to date is the 2005 PrestoSpace report, *Report on Video and Audio Tape Deterioration Mechanisms and Considerations about Implementation of a Collection Condition Assessment Method.* Its authors define "deterioration" as resulting from "an alteration process" in the magnetic tape (Thiebaut, Vilmont, & Lavedrine, 2006, p. 15). Such an alteration process can be identified by four symptoms that lead to loss of performance during playback, including: tape-transport instability, a decrease in signal strength, loss of signal, and/or dropout. The PrestoSpace report echoes comments by Bigourdan, et al. on the complexity of deterioration evaluation processes, alluded to above, concluding that deterioration of videotape:

> depends not only on the intrinsic material stability but also on the player specifications and tolerance to media deterioration as well as tape handling. In addition, the complexity of mass-manufactured tapes with numerous formulations and manufacturing practices result in a variety of deterioration mechanisms. As a consequence, finding a unique deterioration marker is highly challenging and would probably involve much more consequent research efforts. (Thiebaut, Vilmont, & Lavedrine, 2006, p. 42)

The complexity of the magnetic recording processes with regards to deterioration is also found in, arguably, the most authoritative publication on magnetic media tribology—the study of interacting surfaces in relative motion: Bharat Bhushan's 1990, *Tribology and Mechanics of Magnetic Storage Devices.* In it, Bhushan categorizes six distinct kinds of wear mechanisms resulting from playback: adhesive wear; abrasive wear; fatigue; impact by erosion, or percussion; corrosive wear; and electrical-arc-induced wear (Bhushan, 1990, p. 412). Bhushan's analysis of wear is extensive, and he categorizes tape wear as having functional problems rooted in: high friction, loss of reproduced signal amplitude, and excessive dropouts caused by debris adhered to the tape surface (p. 462).

Establishing a Practical Deterioration Metric

The experiment and results presented in this paper engage the complex issues surrounding videotape deterioration as a starting point to establish a practical method and potential justification for libraries and archives to reformat their deteriorating VHS collections. As Legal Counsel Robert Clarida commented in a white paper for the Video At Risk project,

> Because the process of deterioration is very context-dependent, and viewing tapes for visible deterioration is extremely time-consuming, it could be very helpful for the Library to prepare and publish a formal study of the degree to which various factors about

> a VHS tape correlate to the degree of deterioration, even of unplayed VHS tapes. Factors such as age, tape stock used, storage conditions (temperature, humidity), number of plays, and type of playback equipment might all contribute to the speed at which tapes deteriorate, and if a sufficiently large sample of tapes could be analyzed as to these variables the Library might be able to develop a set of reliable criteria for knowing, in advance, how seriously compromised a given tape's condition would be at a given point in the future. This could help the Library plan its digitization efforts more effectively.

Drawing from Clarida's recommendation, PrestoSpace's testing methodology, the facility of machine-based dropout quantification, and its status as both a videotape manufacturing quality-assurance metric and a visually evident on-screen phenomena, the authors chose dropout counts as a point of inquiry and deterioration metric for playback testing of several used, circulating, commercially produced VHS videotapes, as well as in unused, shrink-wrapped, new duplicate VHS copies of the same titles.[3] Importantly, the imperative that deterioration testing be noninvasive and nondestructive—a requirement not normally held to by other scientific inquiries—was another reason for selecting dropout as a testing metric. Nondestructive chemical analyses of circulating VHS tapes in libraries may prove viable and feasible in the future, but were not so at the time of this testing. Unlike analyses of chemical changes in tape binders (for which no information related to their original chemical state is available), dropout affords a means of physical condition assessment of tapes based on the assumption that they were originally in a state of acceptable quality and performance. Other metrics, specifically signal-to-noise ratios, may also prove useful but were not employed here.

Measuring Dropout

Videotape manufacturer literature and specification documentation indicates that dropout count measurements were one of several key quality-assurance metrics by which manufacturers assessed blank VHS videotape. Dropouts result from disruptions in the video signal, caused by an interruption of contact between the videotape recorder (VTR) playback head and the videotape (such as debris clog), or by missing portions of the tape binder that should hold signal information but fail to because of a manufacturing or recording defect. Physical damage such as creasing or crinkling can cause dropout, as well.

As interruptions of the video signal, dropouts are measured by the degree to which they cause the video signal to drop below its nominal decibels (dB) value (Braithwaite, 1989, pp. 3–14). Most tape manufacturers considered a decrease of 20 dB as constituting a dropout, and categorized dropouts by the amount of time required for the signal to return to its nominal value, as measured in microseconds (μs). Here, *Video Magazine*'s editor-in-chief Lancelot Braithwaite explains his methodology's measurement rate of 15 μs:

> In our NTSC video system it takes 63.5 microseconds to make each line of a picture of which 52.5 microseconds actually contain picture information. So a dropout of 15

> microseconds causes a bit more than a quarter of a line to lose information. If the results of each dropout were visible, we would have a very patchy picture, but all VCRs have circuits called dropout compensators. They reduce the effects of dropouts, but they don't eliminate them. (Braithwaite, 1989, pp. 3–14)

Dropout compensator circuitry can replace missing information with stored information about nearby preceding lines of video, which is temporarily stored by the compensator circuitry, often built into a VCR or VTR. While dropout compensators offer replacement chrominance (color) information—but not luminance (achromatic) information—the effect on the viewing experience is less disrupting than a "raw" dropout that appears as a brief horizontal white flash in one of the lines of the onscreen video image. In some cases, even with the presence of compensator circuitry, significant enough amounts of dropout experienced during playback can exceed the compensator's error concealment ability and visually persist as horizontal white flashes. As Dave Rice and Stefan Elnabli point out in their discussion of similar compensation techniques in digital videotape, assessment of error concealment is a "meaningful aspect of the preservation process," as it reveals the extent to which difficulties in reading magnetically encoded signal information can compromise picture integrity (Rice & Elnabli, 2010, p. 5). Again, dropout compensators do not eliminate the existence of dropouts, they merely mask them from the viewer. A VTR's dropout compensator circuitry can be bypassed when the radio frequency (RF) signal of videotape playback is measured through an RF output. This is the method by which accurate dropout counts can be electronically quantified using a specialized piece of dropout counter machinery.

DROPOUT TESTING METHODOLOGY

Investigation Rationale

By employing professional-grade tape signal processing and evaluation equipment, this investigation sought to discover whether a moving image work held on the VHS format might be demonstrated to be "deteriorating" based on quantitative measurement. In the case of still-playable VHS tapes in circulating media collection, what was the correlation between the number of circulations counts and such damage or deterioration, if any? Did tapes with higher amounts of playback register higher dropout counts? Did older tapes perform worse than newer ones? Could such characteristics of age and playback counts be established as contributing to greater deterioration? And: if there were such clear thresholds after which point the tape could be characterized as deteriorating, what were those outer limits?

Technical Approach

Four pairs of commercially produced VHS titles were employed as test tapes in the course of these experiments: Disney's *Bambi*,[4] the educational title *Child-*

hood: Great Expectations,[5] the live-action feature film *Kids*,[6] and Disney's animated feature *Snow White and the Seven Dwarfs*.[7] To measure dropout counts on each of the eight tapes, a calibrated ShibaSoku VH01BZ Dropout Counter at DuArt Film and Video's Restoration Department was employed to measure the RF output of the VTR. All tape playback occurred on a professional-grade JVC BR-S610U S-VHS VTR. Once received by DuArt, the tapes under analysis were acclimatized to the facility's controlled environmental conditions for a period of thirty days, at an average temperature of 69°F. Tapes of matching titles were played sequentially. During playback, each tape was simultaneously monitored for dropout counts per minute using the ShibaSoku Dropout Counter. Two dropout measurements (–20 dB at 5 μs; and –20 dB at 15 μs) were taken at minute intervals for all tapes under testing. All tape playback was also digitized to a Quicktime-wrapped 10-bit uncompressed v210 file for future visual reference. No cleaning of the tapes occurred prior to playback (to ensure condition authenticity and to mimic the circulating library use environment), but video and audio heads on the VTR were cleaned before each playback pass with trichlorotrifluoroethane (CAS 76-13-1), isopropyl alcohol (CAS 67-63-0l), and nitromethane (CAS 75-52-5).

To address the lack of an initial condition assessment, as described above by Bigourdan et al., this experiment tested four used and four unused pairs of the same titles: one taken from the circulating VHS collection at the Avery Fisher Center for Media at NYU Libraries; and, the second a new, unused copy, from the same era, in original shrink-wrap, purchased from after-market vendors via Amazon.com. Great care was taken to ensure that new duplicates were of the same edition, produced by the same distribution company, and with identical packaging. It was impossible to verify if duplicates were made at identical commercial tape duplicator locations; however, similar machine identification and barcode markings on the physical VHS carriers suggest that they were, at least, made by the same duplication company. Combined with the expense of such testing, the difficulty in finding matching pairs of videotape titles (used and unused) in the marketplace significantly limited the experiment's test set of tapes.

Comparing used, circulating copies against new, unused copies, was thought to hold promise in isolating the effects of playback (documented by library cataloging systems as circulations) on tape deterioration. A third set of metrics for condition assessment comparison were measurements taken from published manufacturer quality-control standards and literature regarding dropout counts of new, blank videotape stock.

Acknowledged Test Liabilities

Environmental Storage

Temperature and humidity conditions for storage of each tape may well have been different, and this difference may sway test result accuracy.

Differences in Packaging

While both used and unused *Kids* tapes were 1996 Vidmark releases, and both contain similar white machine-inscribed markings on their tape spines (suggesting they were duplicated by the same manufacturer), these markings are also not identical. The etched pattern on each tape's physical carrier shell differs slightly.

Limited Manufacturer Information

As with the guarded details of manufacturer recipes for tape binder compositions, there is relatively limited manufacturer literature on the technical details of videotape. The manufacturer dropout count measurements cited in this study come from only two manufacturers (Sony and 3M) from 1991 to 1992, and it cannot be determined which manufacturer's tape stock was employed in the creation of the titles under testing.

Back-Coating

In higher-quality tape stock, the back surface of the tape (opposite the emulsion side that faces the video playback and recording heads) is usually coated with carbon to reduce static generated by friction when travelling through the cassette past the metal tape guides. A preliminary inspection of each test tape for carbon-backings yielded interesting results: both the new, unused tapes for *Childhood: Great Expectations* and *Snow White and the Seven Dwarfs* featured carbon-backed videotape, while their circulated counterparts did not. This finding revealed important realities about the consistency of tape stock during large duplication runs of commercially created titles in processing plants. As with the preceding acknowledged test liabilities, however, these are unavoidable realities that contravene ideal experiment control environments.

DROPOUT TESTING RESULTS AND DISCUSSION

The following charts depict dropout counts for each of the four pairs of titles at both measured dropout sensitivities (–20 dB at 5 μs; and –20 dB at 15 μs). Readers will note that each title's pair of graphs represent measurements performed simultaneously, at different sensitivities. Used, circulated tapes appear as light gray bars. Unused, new tapes appear as black bars. Minute-by-minute dropout counts can be found in the appendices.

I. *Bambi*

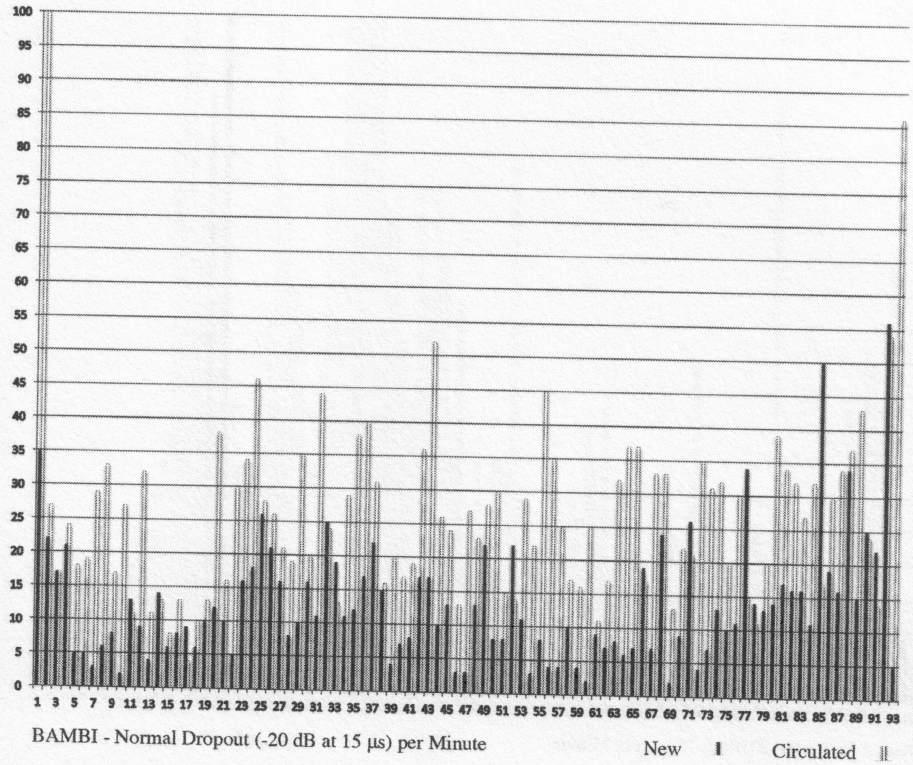

Figure 13.1.

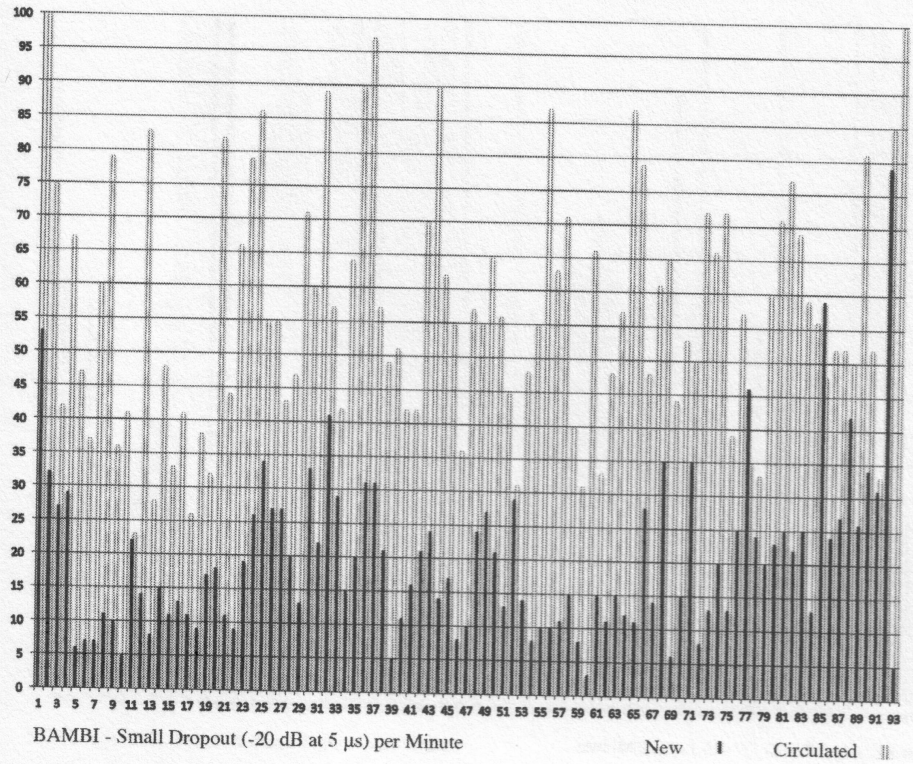

Figure 13.2.

II. *Childhood: Great Expectations*

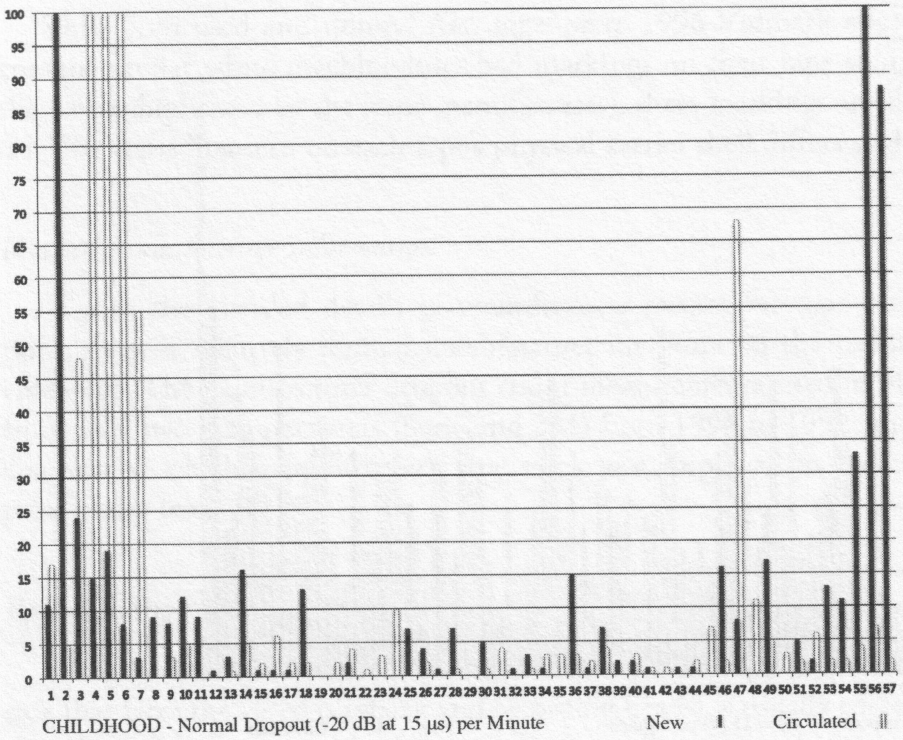

Figure 13.3.

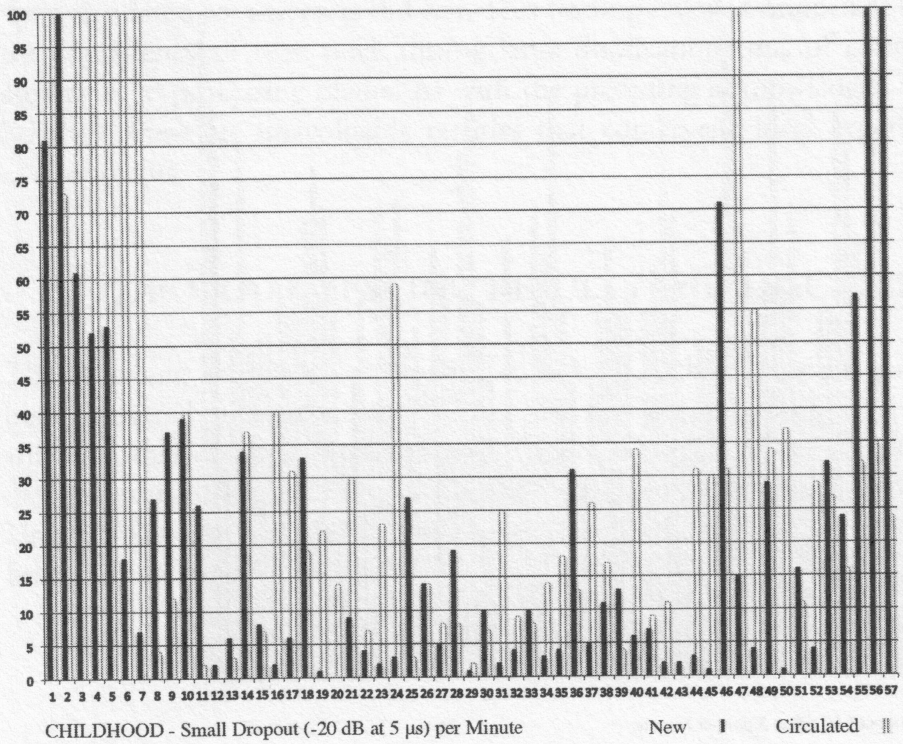

Figure 13.4.

III. *Kids*

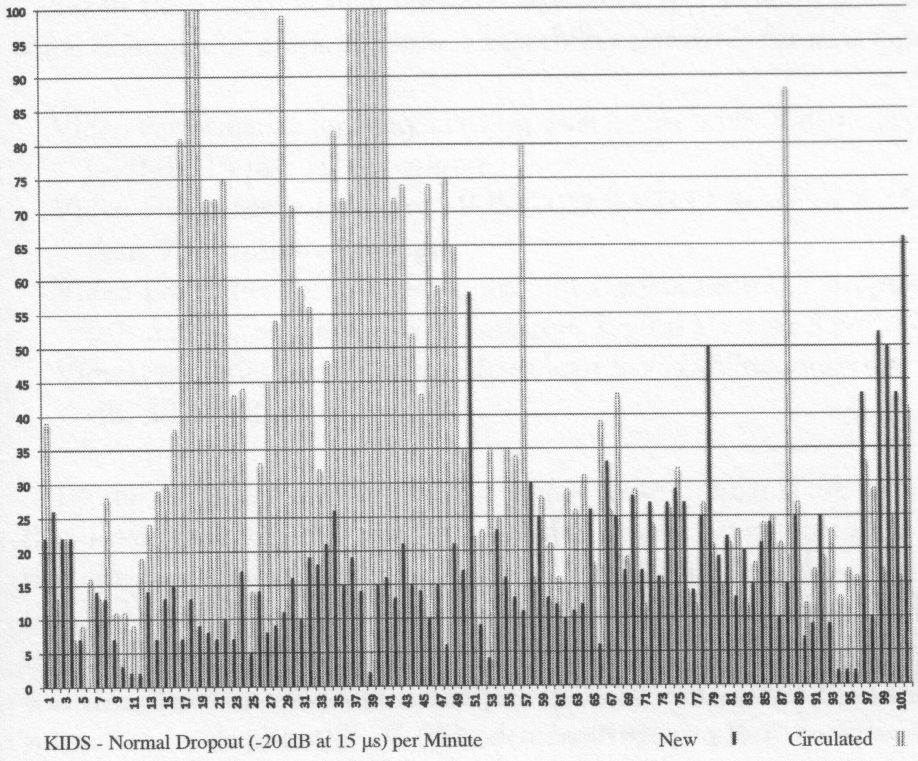

Figure 13.5.

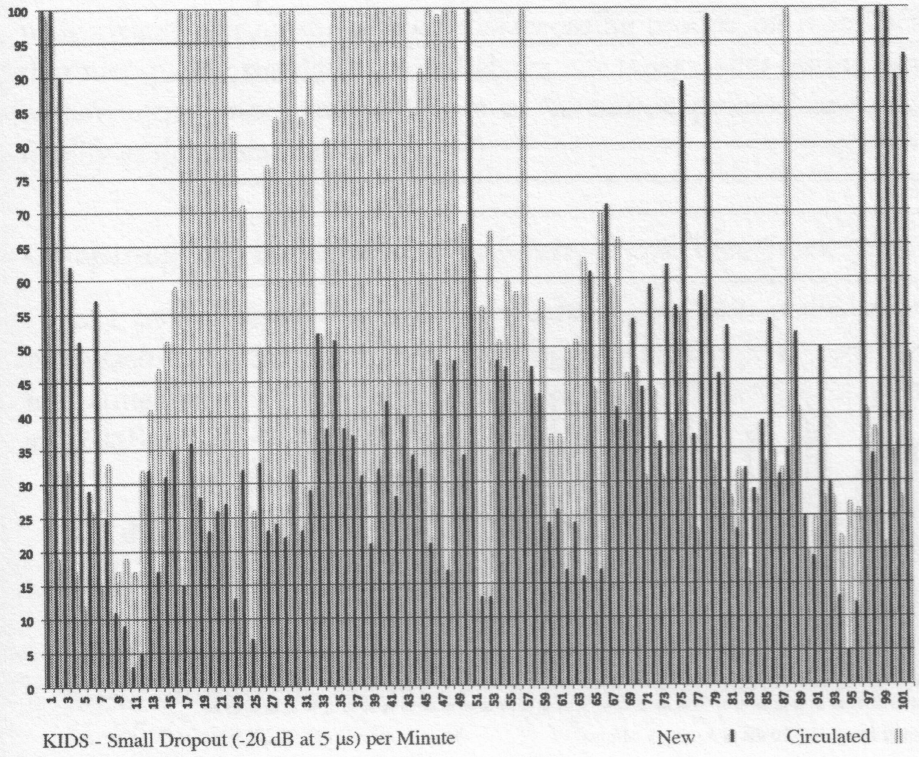

Figure 13.6.

IV. *Snow White and the Seven Dwarfs*

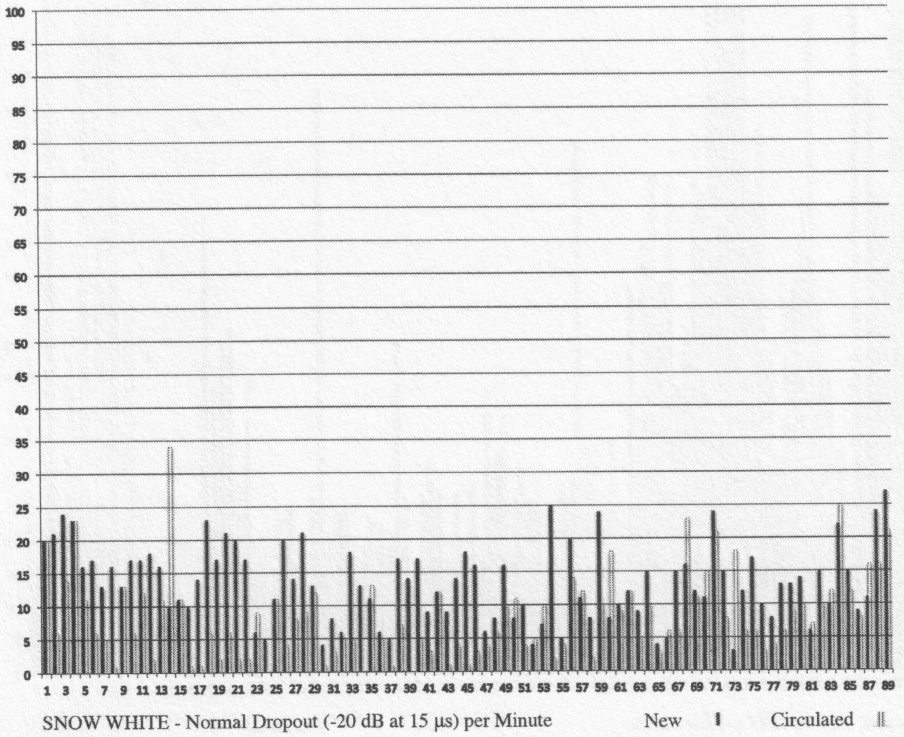

Figure 13.7.

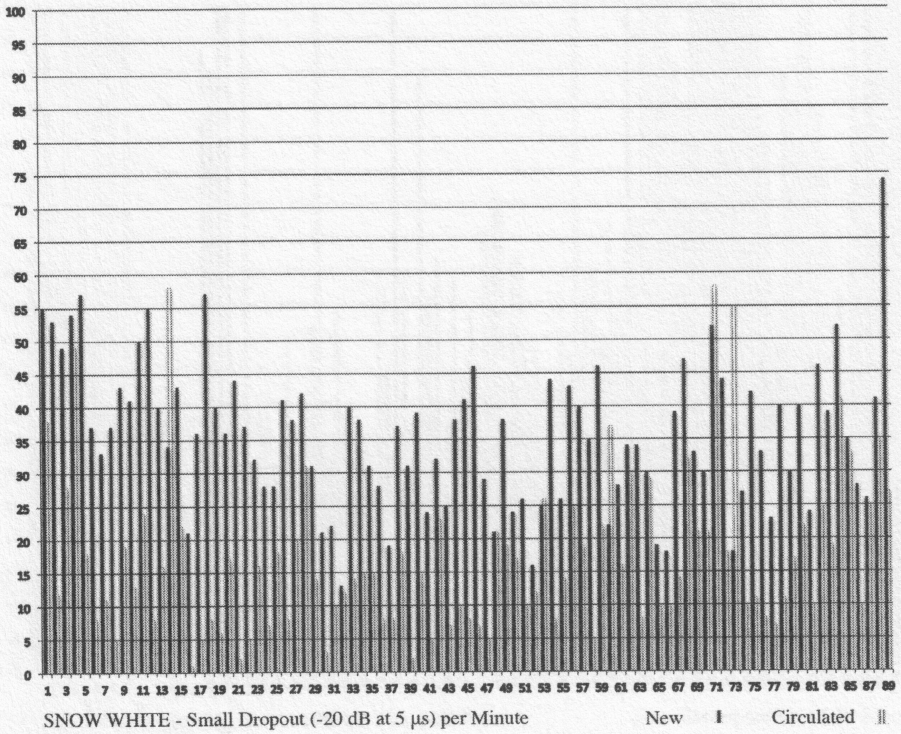

Figure 13.8.

Comparing Test Results with Blank Tape Stock Manufacturer Literature

Taken from original manufacturer tape stock specification pamphlets, below are some examples of dropout count acceptability standards for new tape stock:

Video Performance for Sony's Professional Grade VHS Video Cassettes,[8] dropouts (–20dB, 15 μs): 10 per minute.
Video Performance for Sony MQST-120 S-VHS,[9] dropouts (–15dB, 20 μs): less than 5 per minute (average).
Video Properties for 3M Broadcast VHS videocassettes,[10] dropouts (–20 dB, 15 μs): maximum average: 6 per minute. Typical average: 3 per minute.
Video Properties for 3M Master Broadcast S-VHS Videocassettes,[11] dropouts (–12 dB, 30 μs): 8 per minute.

By the early 1990s, the era from which these standards are available, it appears that fewer than ten dropouts per minute was an acceptable threshold of quality that dropout counter sensitivity metrics (in dBs and μs) may have been adjusted to achieve. Acceptability thresholds for videotape also appear to have changed over time. According to *Video Magazine*, "in 1982, fewer than 15 blemishes per minute was considered excellent. [In 1990] a tape must have fewer than five blemishes per minute to be rated excellent" (Woodcock, 1989, p. 16).

Likely due to a combination of deterioration contributing factors—age, possible hydrolysis, suboptimal environmental conditions, and (for some) amount of playback wear—all tapes tested in our experiment failed manufacturer quality standards for acceptable dropout counts. If we are to assume that these tape copies were originally created during the duplication/recording process on manufacturer tape stock that met quality standards quoted above, the tapes under testing can be understood to have experienced some manner of "alteration process" and should be seen to qualify as deteriorating.

Comparing Test Results with Third-Party Blank Tape Stock Tests

As a service to its readership, an exhaustive 1989 quality survey test of tape manufacturers blank stock by *Video Magazine* (1989, p. 12) established the following ratings hierarchy for dropout count testing of blank videotape stock (measured at –20dB, 15 μs):

0–5 dropouts per min.	=	Excellent
6–10 dropouts per min.	=	Very Good
11–20 dropouts per min.	=	Good
21–30 dropouts per min.	=	Average
31–40 dropouts per min.	=	Fair
41–50 dropouts per min.	=	Weak
over 50 dropouts per min.	=	Poor

Of the sixty-five stocks from twenty-one manufacturers *Video Magazine* tested, most manufacturers' blank stocks fell in the upper half of this hierarchy, supporting the validity of manufacturer-stated measurement literature. Only two stocks satisfied the "Poor" rating for dropout counts, none satisfied the next category of "Weak," and only one qualified as "Average" (*Video Magazine*, 1989, pp. 18–23).

Using this hierarchy for comparison, the tapes under testing in this experiment averaged the following dropouts per minute (measured at –20dB, 15 μs):

Bambi (used, circulating)	27.0 dropouts per min. [Average]
Bambi (new, unused)	13.3 dropouts per min. [Good]
Childhood: Great Expectations (used, circulating)	38.3 dropouts per min. [Fair]
Childhood: Great Expectations (new, unused)	13.7 dropouts per min. [Good]
Kids (used, circulating)	17.2 dropouts per min. [Good]
Kids (new, unused)	41.1 dropouts per min. [Weak]
Snow White and the Seven Dwarfs (used, circulating)	8.3 dropouts per min. [Good]
Snow White and the Seven Dwarfs (new, unused)	13.4 dropouts per min. [Good]

Dropout measurements for all of the tapes under testing in this experiment, with the exception of one, fail to surpass the "Good" categorization and two of them rate in the lower rungs of this hierarchy.

Comparing Test Results with Third-Party Tests of Commercially Produced Tapes

While instructive, charting dropout counts in commercially produced tapes in this experiment against dropout measurements of blank, new videotape stock is somewhat of an imperfect comparison. Ideally, commercially produced tapes would be measured against commercially produced tapes, and a 1990 investigation by the trade publication *Video Review* makes such a comparison possible.

Titled, "Video's Dirty Secret," this study by author Ron Goldberg (1990) uses quantitative and qualitative testing to reveal defects in over 60% of the commercially produced tapes tested, finding that even tapes of titles duplicated for larger Hollywood studio releases evidenced excessive dropout counts—the principal evaluation metric employed by Goldberg (pp. 36–39).

None of the Video At Risk (VAR) test tape titles overlap with those tested by *Video Review*, but Goldberg's findings are especially relevant, as the VAR test strategically selected two Disney animated feature titles that carried the THX label of quality—a quality certification system bestowed on only the highest-quality duplicated material. Among the new, unused copies of those titles, *Bambi* failed to

perform significantly better than its used, circulated counterpart, and *Snow White and the Seven Dwarfs* actually performed worse than its used, circulated counterpart.

Goldberg's conclusion is akin to an indictment of videotape duplicators looking to save money by using inferior-grade blank tape stock in the duplication process. The notion that the tape duplication industry could utilize substandard tape stocks is not surprising. As one former tape duplication industry employee described it, "tape duplication was a penny-pinching business."[12] Goldberg's study found that of the thirty-six tapes tested (pairs of eighteen titles) more than one-third of them exceeded dropout rates of fifty per minute (measured at –20dB, 15 μs).[13]

The suggested inconsistency among duplicators' quality-assurance processes that Goldberg uncovered may be echoed by our experiment. The two THX-certified Disney titles had discrepancies in each tape's physical characteristics: only one of the Disney titles (new, unused *Snow White and the Seven Dwarfs*) contained anti-static back-coating on the tape—a quality measure intended to extend the life of the tape and protect against damage. Moreover, if inferior tape stock was, in fact, so commonly employed by tape duplicators, the authors believe that the case for deterioration qualification is strengthened: tape stock of inferior manufacturing quality is likely to result in decreased stability and performance, over time, when compared with tape stock that meets the high manufacturer quality-control standards cited above.

Impact of Playback and Circulation Counts on Deterioration

The circulation statistics for tapes tested in this experiment appear below:

Bambi (used, circulating)	45 circulations
Bambi (new, unused)	0 circulations
Childhood: Great Expectations (used, circulating)	248 circulations
Childhood: Great Expectations (new, unused)	0 circulations
Kids (used, circulating)	203 circulations
Kids (new, unused)	0 circulations
Snow White and the Seven Dwarfs (used, circulating)	17 circulations
Snow White and the Seven Dwarfs (new, unused)	0 circulations

Looking at the two highest-circulated titles, *Childhood: Great Expectations* and *Kids*, a pattern may be said to corroborate claims that tapes experiencing high levels of playback experience a burnishing or "calendaring" effect whereby the videotape binder becomes so well-worn that the rate of subsequent physical deterioration diminishes, or plateaus. The specifics of calendaring resulting from VTR head-to-tape physical contact are reflected in the research of Osaki et al., and Bhushan, cited above. But, for the purposes of this inquiry it can be stated that highly circulated tapes are likely to have already experienced such a degree of physical wear and deterioration that by their 200th-odd pass the microscopic roughness of the tape

binder has been significantly worn down—in essence, polished. This fact may be reflected by the dropout counts in *Childhood: Great Expectations*, yet inconsistency in tape backing between the used and the unused copies makes such a determination difficult to definitively assert.[14] What this calendaring effect does directly suggest is that libraries wishing to detect deterioration in their circulating VHS tapes begin such evaluations with the most highly circulated titles in their collections.

Impact of Age on Deterioration

For tapes under testing in this experiment no noticeable trend can be asserted with regard to the impact of age alone on quantifiable deterioration factors, such as dropout counts. However, insofar as both used and unused copies of all titles failed manufacturer quality-control standards, age likely plays a core contributing role in the deterioration-associated "alteration processes" taking place in the tape binder. While this may not be so surprising a finding, it does directly suggest that libraries wishing to detect deterioration in their circulating VHS tapes begin such evaluations with the oldest titles in their collections.

Impact of Environmental Conditions

The possibility that NYU-Libraries' environmental conditions played a corrupting role and contributed to potential tape hydrolysis remains. It is clear that such environmental conditions may fall short of ISO 18934 recommendations for temperature, relative humidity, and stability (which should not exceed 73°F for 20% RH and should not exceed 52°F for 50% RH) (ISO, 2006). However, the conditions at NYU-Libraries are most likely in keeping with those conditions at other circulating video libraries, and it is unlikely that many other libraries store their circulating VHS collections in ISO 18394 compliant conditions.

GENERAL IMPRESSIONS AND CONCLUDING OBSERVATIONS

The dropout count testing results of these experiments demonstrate that all tapes considered failed quality standards set by tape stock manufacturers. These test results were surprising as the authors did not foresee such resulting high dropout counts for the tapes, and as we had originally anticipated some manner of specific correlation between circulation and dropout—namely, that highly circulated tapes would demonstrate a more contextual trend in dropout counts. While the small data set from this testing may make it difficult to definitively assert such trends or offer definitive conclusions about the deterioration status of other videotapes in the AFC circulating collections, it is clear that these tapes no longer meet any of the available quality and performance documentation that they were believed to have met in their original

state at the time of production and/or manufacture.[15] Whether or not a tape under testing in its original state adhered to such standards seems moot, as such a retroactive determination is impossible for these (and most other) tapes. Most importantly, the authors strongly believe that all evidence suggests that the complex factors involved in the "alteration processes" of deterioration will only serve to intensify the deteriorating condition of any given videotape with time. The evident deterioration relative to dropout counts is likely only the first in a litany of deterioration factors for all tapes tested in the course of this experiment.

Unlike myriad other potential deterioration factors, dropout count thresholds specified by tape manufacturers actually do exist. As such, we believe that such quantified dropout counts offer one of the least subjective forms of noninvasive evidence for videotape deterioration currently available. From the legal perspective of justifying preservation reformatting under Section 108(c), we would recommend such dropout count measurement, as it can at least enable contrast with subsequent physical condition states, even if only at future points in time. While one can, perhaps, never know an original dropout count measurement for a specific videotape item at the point-of-creation, documenting current dropout rates for library collections can be seen as invaluable data for deterioration assessments down the road. The authors also concur with the legal analysis of Counsel Robert Clarida that, given the absence of a specific requisite quantity of deterioration in the language of the law, as small a spike in dropout counts as those lasting even a few minutes would certainly qualify a tape as "deteriorating."

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NOTES

1. October 10, 2012. "[Videolib] Confronting a campus wide VHS DEATH Deadline."

2. See H. Rep. 94–1476 at p. 73, under the heading "Reproduction and uses for other purposes":

> A problem of particular urgency is that of preserving for posterity prints of motion pictures made before 1942. Aside from the deplorable fact that in a great many cases the only existing copy of a film has been deliberately destroyed, those that remain are in immediate danger of disintegration; they were printed on film stock with a nitrate base that will inevitably decompose in time. The efforts of the Library of Congress, the American Film Institute, and other organizations to rescue and preserve this irreplaceable contribution to our cultural life are to be applauded, and the making of duplicate copies for purposes of archival preservation certainly falls within the scope of "fair use."

3. The term "new" should be understood as meaning an unused copy of the same title, purchased in its original shrink-wrap packaging, and manufactured at the same time and era as the used, circulating copies. As VHS videotapes are no longer manufactured, references to such "new" tapes do not mean tapes that were recently manufactured.

4. *Bambi* [Fully Restored 55th Anniversary Edition], directed by David Hand (1942; Burbank, CA: Walt Disney Home Video, 1997), VHS.

5. *Childhood: Great Expectations*, directed by Geoff Haines-Stiles (1991; New York: Ambrose Video, 1991), VHS.

6. *Kids*, directed by Larry Clark (1995; Marina Del Rey, CA: Vidmark Entertainment, 1997), VHS.

7. *Snow White and the Seven Dwarfs* [Platinum Edition], directed by David Hand (1937; Burbank, CA: Walt Disney Home Video, 2001), VHS.

8. Sony Professional Grade VHS Video Cassettes, Sony Corporation specifications sheet, 1991. Catalog no. ACG-5140-TKY-9109-P1-005.

9. Sony MQST S-VHS videocassettes, Sony Corporation specifications sheet, 1992. Catalog no. ACG-5164-TCS-9206-010.

10. Broadcast VHS tapes, specifications Sheet, 3M, 1991. Catalog no. 84-9811-4338-5. According to the Test Notes, "during playback of a 50% gray level signal, the unlimited RF signal is monitored for dropouts exceeding 20 dB in depth and 15 microseconds in length."

11. Master Broadcast S-VHS Videocassettes, specifications sheet, 3M, 1991. Catalog no. 84-9811-4340-1. Defined in Test Notes as, "any tape defect that produces a 12dB [for] 30 m sec or greater is electronically counted as a dropout."

12. Maurice Schecter, in conversation with the authors, December 2012.

13. While Goldberg's investigation does not specify dropout dB size measured, past *Video Review* dropout count testing employed a –18 dB measurement (Measuring tape, 1990, 31–36).

14. The severe spike in dropout at the beginning of the used copy of *Childhood: Great Expectations* can be attributed to physical crinkling damage—affirmation of the dropout metric's ability to document videotape problems.

15. Indeed, the potential data set encompassing any representative percentage of VHS tapes and stocks ever produced would be far too enormous and unscalable.

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